# The NESCAUM Method of Estimating Aircraft Emissions

**Presentation to the**

**OTC Mobile Source Committee**

**December 5, 2001**

**Baltimore-Washington International Airport**

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# Presentation Outline

- The standard method for calculating aircraft emissions
- The need for an alternative to EDMS
- Differences between the NESCAUM Model and EDMS
- Differences between EDMS and NESCAUM inputs
- Airports studied and results

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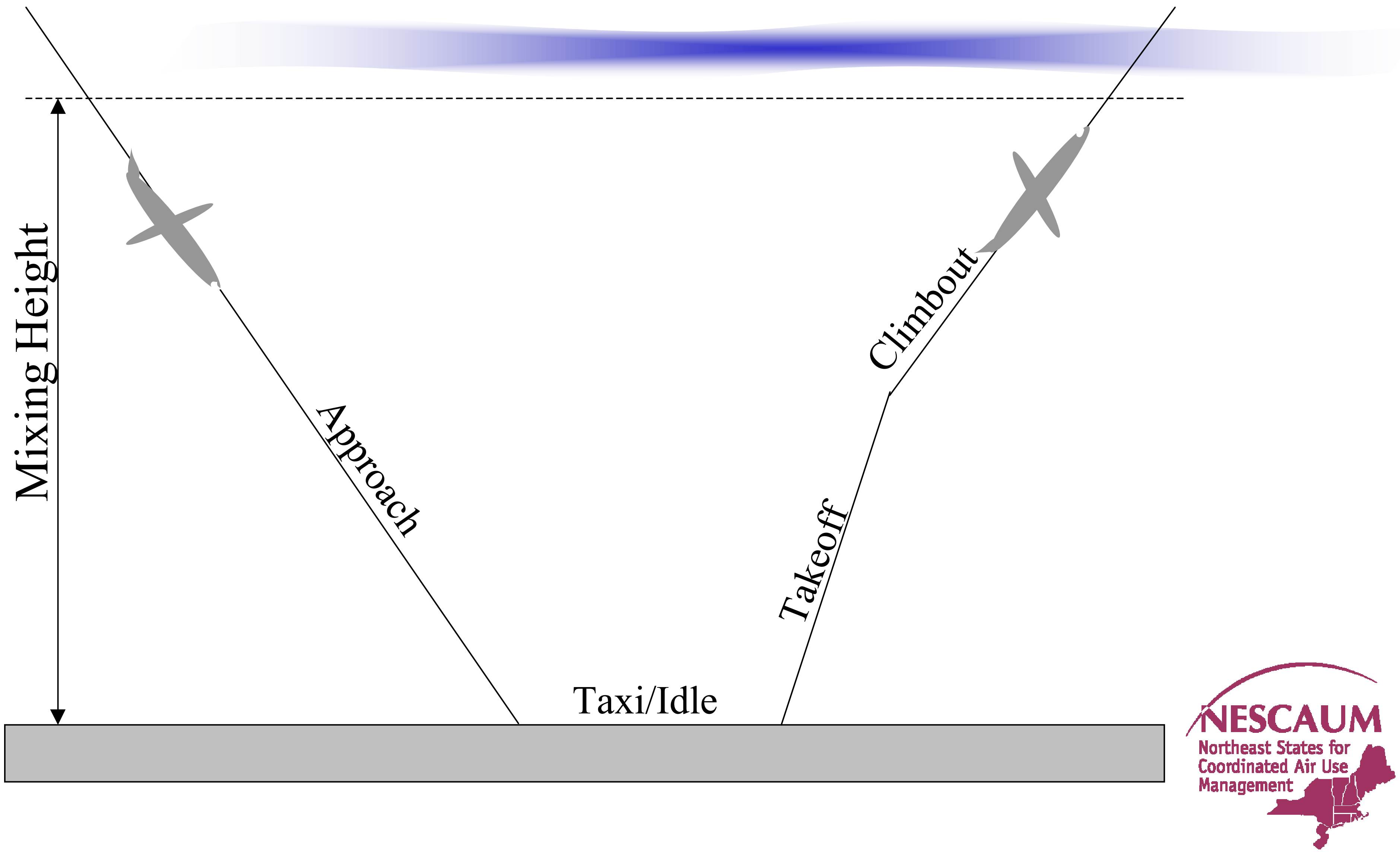
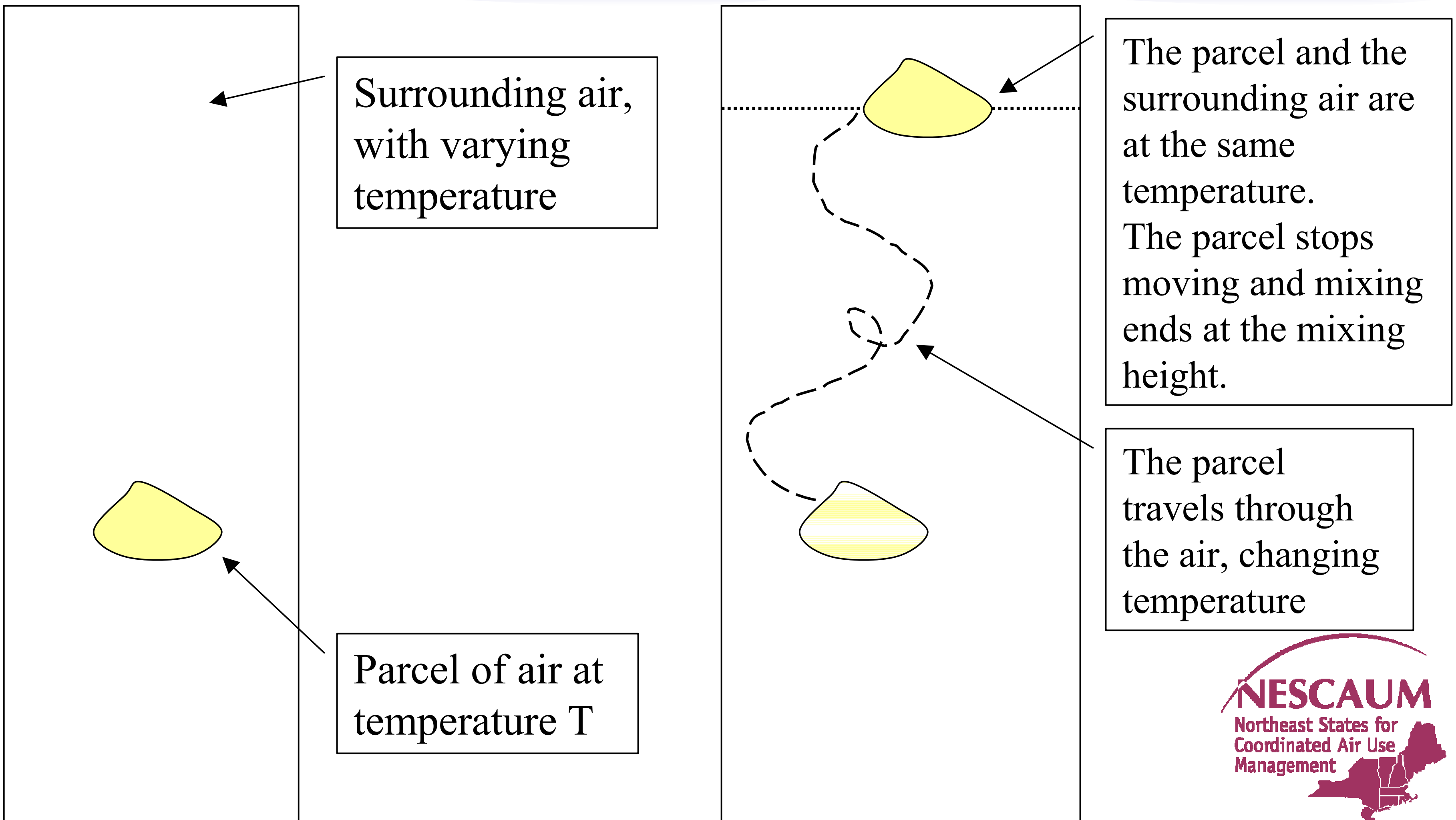
# The Landing and Takeoff (LTO) Cycle



# What is the Mixing Height?

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# Default Time-in-Mode for 3000 foot Mixing Height

| (time in minutes) | Commercial Aircraft | Air Taxi | General Aviation | Changes with Mixing Height |
|---|---|---|---|---|
| Takeoff | 0.7 | 0.5 | 0.3 | No |
| Climbout | 2.2 | 2.5 | 5.0 | Yes |
| Approach | 4.0 | 4.5 | 6.0 | Yes |
| Taxi/Idle | 26.0 | 26.0 | 16.0 | No |

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# Equation for Aircraft Emissions

| | |
| --- | --- |
| For each mode: *Emission Factor*fuel flow*time-in-mode* calculate for all modes and sum | Emissions for one engine |
| ↓ Multiply by the number of engines on the aircraft | Emissions for one aircraft |
| ↓ Multiply by the number of LTOs for that aircraft | Annual emissions for each aircraft |
| ↓ Sum all aircraft emissions | Total Airport Emissions |

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# EDMS Simplifies the Airport Fleet Mix

- EDMS
  - One engine assigned to each aircraft

    e.g., Boeing 757-200 can be outfit with any of four engine types
  - Same engine used for all aircraft at an airport
  - Difficult to use

- LTO and aircraft fleet mix data are available at a finer level of detail

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# Key Differences Between the NESCAUM Model and EDMS

- Weighted averages of the engines used on each airline's fleet of aircraft
  - Continental's Boeing 727-200s
    - 4 engine models on 9 planes
  - Continental's Boeing 737-300s
    - 2 engine models on 65 planes
  - and FedEx's Airbus 310-200s
    - 4 engine models on 40 planes

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# Detailed LTO data is available for every airport

```
<BOSTON
%AIR TRANSPORT        %TOTAL %*DC-8-62      %          %      3%          3%
%                     %      %*DC-8-71      %          %      9%          9%
%                     %      %*DC-8-63      %          %      2%          2%
%                     %      % ALL TYPES    %          %     14%         14%
%AIRTRAN              %TOTAL % B-737-100/200 %     237%       %        237%
%                     %      % DC-9-30      %    1,868%       %      1,868%
%                     %      % ALL TYPES    %    2,105%       %      2,105%
%AMERICA WEST         %TOTAL % B-757-200    %      29%      2%         31%
%                     %      % A-320-200    %    2,425%      4%      2,429%
%                     %      % A-319        %      600%       %        600%
%                     %      % ALL TYPES    %    3,054%      6%      3,060%
```

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# Key Differences Between the NESCAUM Model and EDMS (cont.)

| | C | D | Z | AA | AB | AC | AD | AE |
|---|---|---|---|---|---|---|---|---|
| 89 | | | | | | | | |
| 90 | | | Continenta | Co(ntinenta | Co(ntinental | Delta | DHL | Eastwind |
| 91 | Aircraft | | | Express | Micronesia | | | |
| 92 | | | | | | | | |
| 93 | B-727-100 | | xx | xx | xx | xx | xx | xx |
| 94 | DC-9-30 | | 5 | xx | xx | xx | xx | xx |
| 95 | FOKKER 100 | | xx | xx | xx | xx | xx | xx |
| 96 | MD-80 | | 6115 | xx | xx | 2164 | xx | xx |
| 97 | B-727-200 | | 4 | xx | 0 | 9230 | xx | xx |
| 98 | B-757-200 | | 149 | xx | 0 | 4336 | xx | xx |
| 99 | L-1011/100/20 | | xx | xx | xx | 292 | xx | xx |
| 100 | EMBRAER-145 | | xx | 190 | xx | xx | xx | xx |
| 101 | B-737-500 | | 580 | xx | xx | xx | xx | xx |
| 102 | B-737-300 | | 2042 | xx | 0 | 0 | xx | 384 |
| 103 | 737-800/900 | | xx | xx | xx | 1 | xx | xx |
| 104 | B-737-100/200 | | 0 | xx | xx | 6663 | xx | 677 |
| 105 | B-767-300 | | xx | xx | xx | 1261 | xx | xx |
| 106 | B-767-200 | | xx | xx | xx | 647 | xx | xx |
| 107 | MD-11 | | xx | xx | xx | 0 | xx | xx |
| 108 | L-1011-500 | | xx | xx | xx | 778 | xx | xx |

← Easy spreadsheet input

Simple summary output →

| | CO | HC | NOx | SO2 |
|---|---|---|---|---|
| Domestic Flights: | 1497.8 | 316.2 | 1985.5 | 202.4 |
| International Flights: | 216.0 | 54.7 | 306.6 | 21.8 |
| All Flights: | 1713.8 | 370.9 | 2292.1 | 224.2 |
| | | | | |
| Domestic APU Use: | 285.1 | 17.8 | 161.9 | 30.0 |
| International APU Use: | 17.0 | 1.0 | 20.3 | 3.3 |
| All APU Use: | 302.1 | 18.8 | 182.3 | 33.3 |
| | | | | |
| Domestic Flight + APU: | 1782.9 | 334.0 | 2147.4 | 232.4 |
| International Flight + APU: | 233.0 | 55.7 | 326.9 | 25.1 |
| All Flight + APU: | 2015.9 | 389.7 | 2474.4 | 257.5 |

# Key Differences Between the NESCAUM Model and EDMS (cont.)

- Auxiliary Power Units* (APUs) handled in the same model
  - Same weighted average calculation of APUs on each airline's fleet of aircraft
  - Input time-in-use by airline/aircraft combination
  - Ability to specify how often gate power is used instead of APU

* APUs are small turbine engines used to supply power to the aircraft while it is parked at the gate.

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# Limitations of the NESCAUM Model

- Airline/aircraft inventory is included for one calendar year
  - Can be fudged for nearby calendar years
- Forecast inventories require an additional model
  - Forecast model is also year-dependent, with some flexibility for use with other years
  - Forecast-year LTOs must be developed for use with the forecast model from FAA projections

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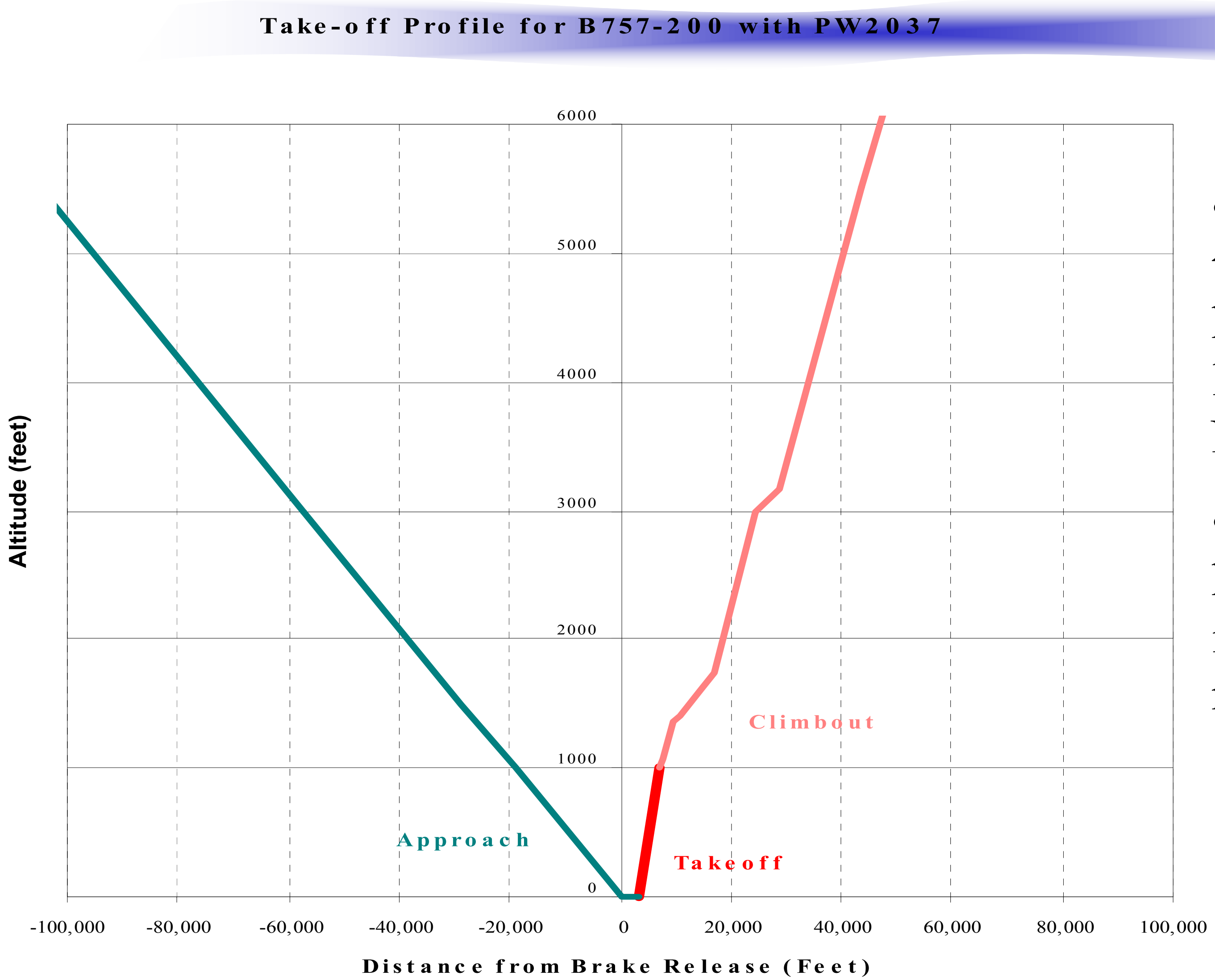
# FAA Flight Profile Data: Takeoff extends to 1000 feet




- Longer takeoff time means longer high-power operation, leading to higher NOx emissions
- Higher mixing height dramatically increases time-in-mode

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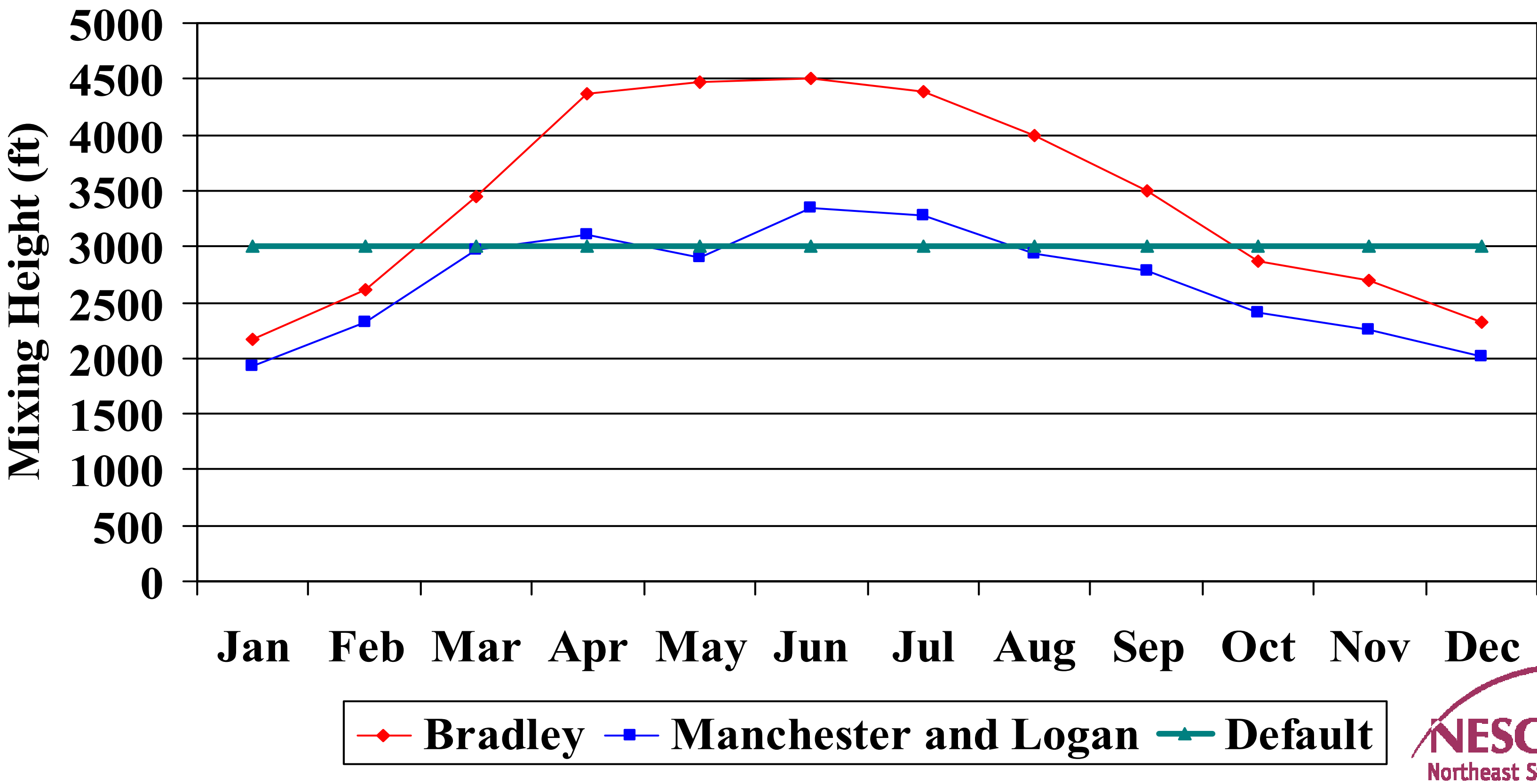
# Monthly Mixing Heights

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# Other differences in inputs

- LTOs by airline/aircraft combination
- Monthly airport-specific taxi/idle times
  - from DOT Bureau of Transportation Statistics
- APU times estimated from airport arrival/departure schedules

# Similar Method for Air Taxi and General Aviation Aircraft

- Smaller planes, but the same idea
- National registry data used for aircraft/engine combinations
- Weighted averages of aircraft/engine combinations and fleet mix (piston, turbine, and helicopters)
- Time-in-mode adjusted for mixing height

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# Logan International Airport Boston, MA

- Largest airport in New England
- 27 million passengers in 1999
- Expect 37.5 million passengers in 2015
- Hoping to spread growth to regional airports

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# Bradley International Airport Hartford, CT


Bradley Overview

- 6.3 million passengers in 1999, 7.3 million passengers in 2000
- Bradley is a "large" airport as of 2000.
- Currently adding a new terminal

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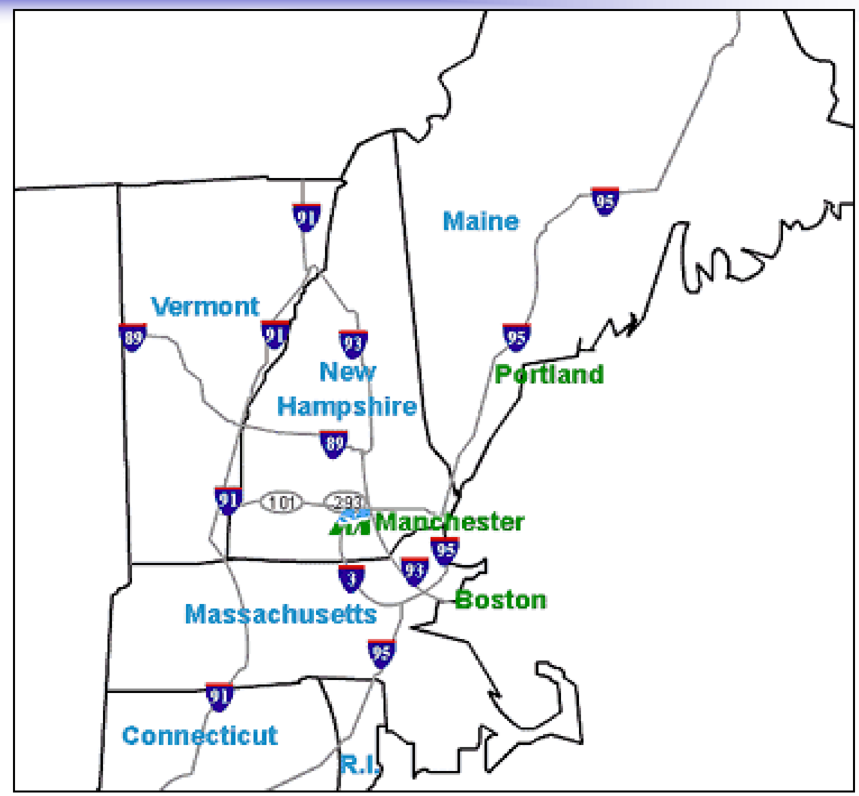
# Manchester Airport
# Manchester, NH

- Served 1.1 million passengers in 1997
- Served 2.8 million passengers in 1999
- Manchester is now a “medium” airport.
- Southwest Airlines brought low fares, tremendous growth




Manchester Photos

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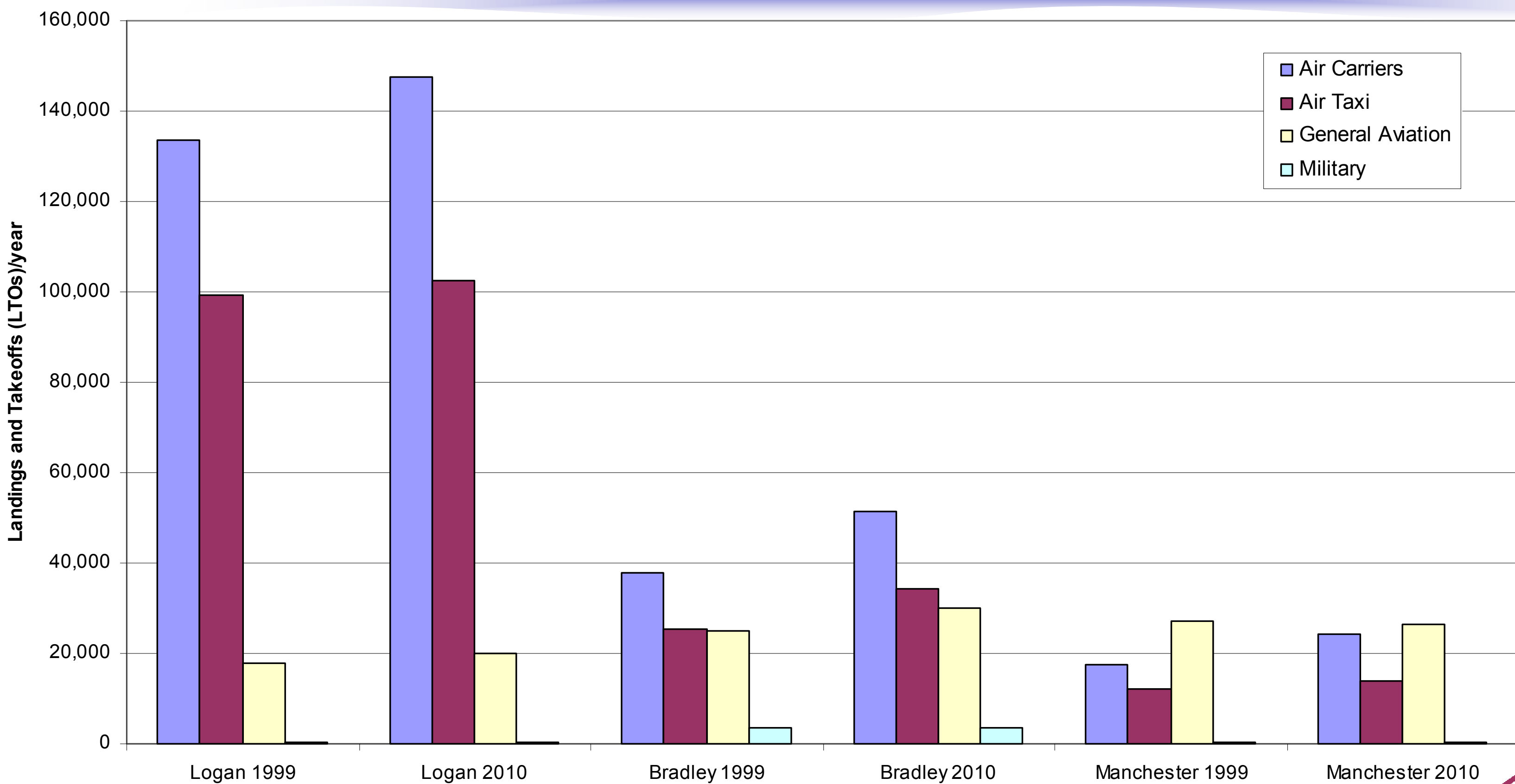
# LTOs at the Three Airports

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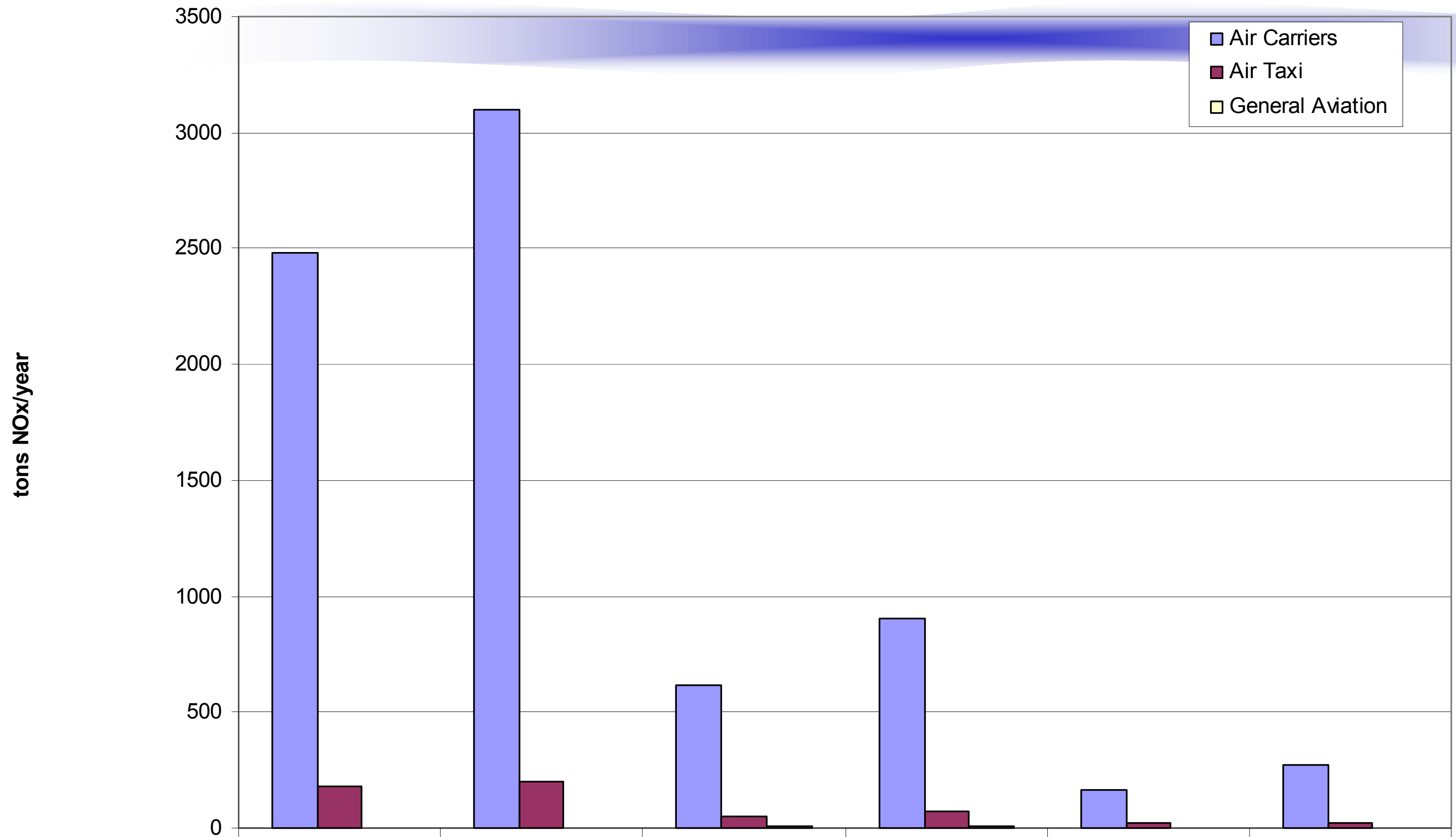
# NOx Emissions -- NESCAUM Estimate




| | Logan 1999 | Logan 2010 | Bradley 1999 | Bradley 2010 | Manchester 1999 | Manchester 2010 |
|---|---|---|---|---|---|---|
| Air Carriers | 2482 | 3101.1 | 620.3 | 901.7 | 164.2 | 269.4 |
| Air Taxi | 179.7 | 201.7 | 52.3 | 70.6 | 20 | 23.2 |
| General Aviation | 2.4 | 2.8 | 3.9 | 4.7 | 3.3 | 3.2 |

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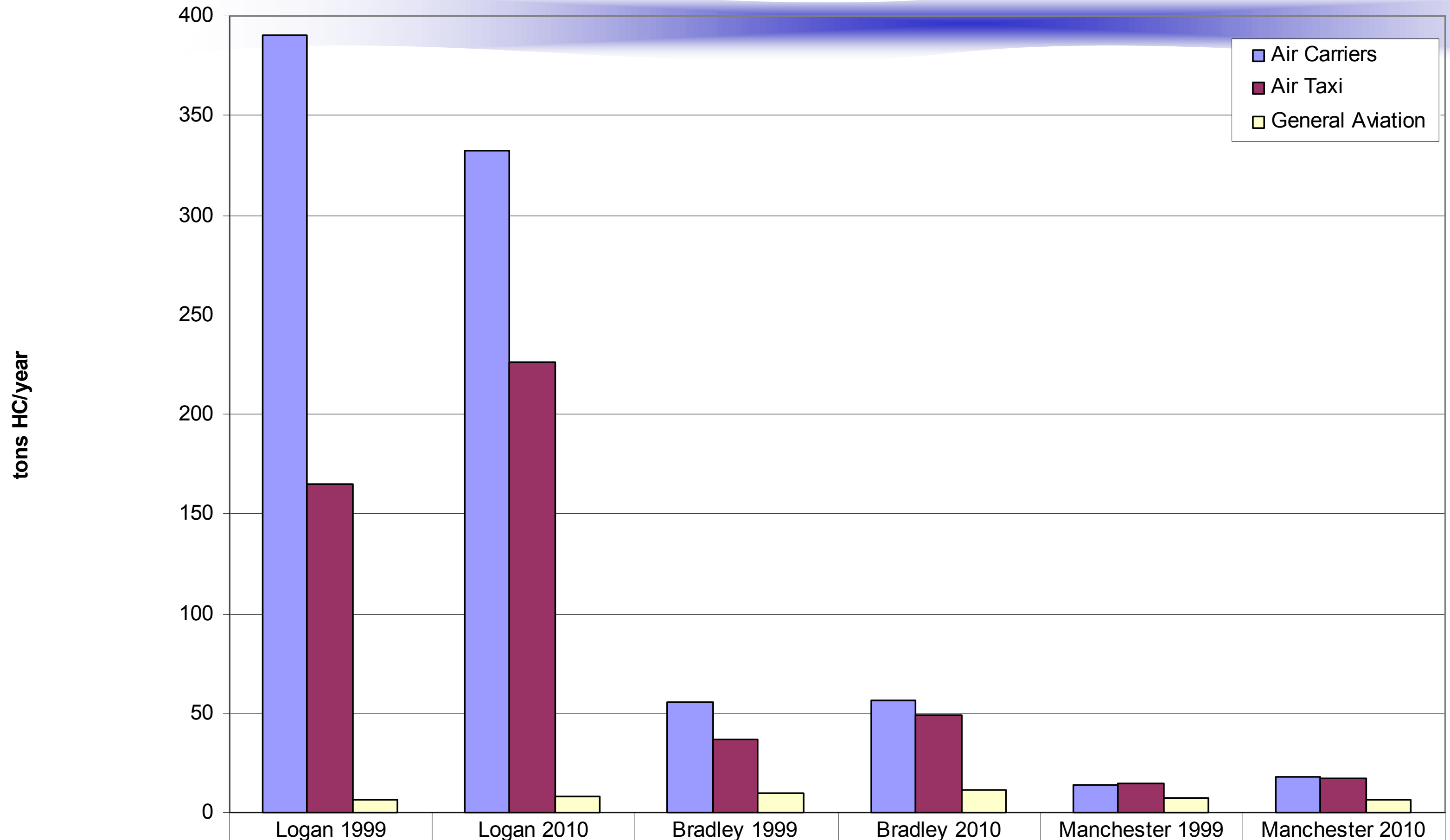
# HC Emissions -- NESCAUM Estimate




| | Logan 1999 | Logan 2010 | Bradley 1999 | Bradley 2010 | Manchester 1999 | Manchester 2010 |
|---|---|---|---|---|---|---|
| Air Carriers | 390.1 | 332.4 | 55.8 | 56.7 | 13.6 | 17.8 |
| Air Taxi | 165.2 | 226.5 | 36.4 | 49.2 | 14.8 | 17.2 |
| General Aviation | 6.8 | 8.1 | 9.8 | 11.8 | 7 | 6.7 |

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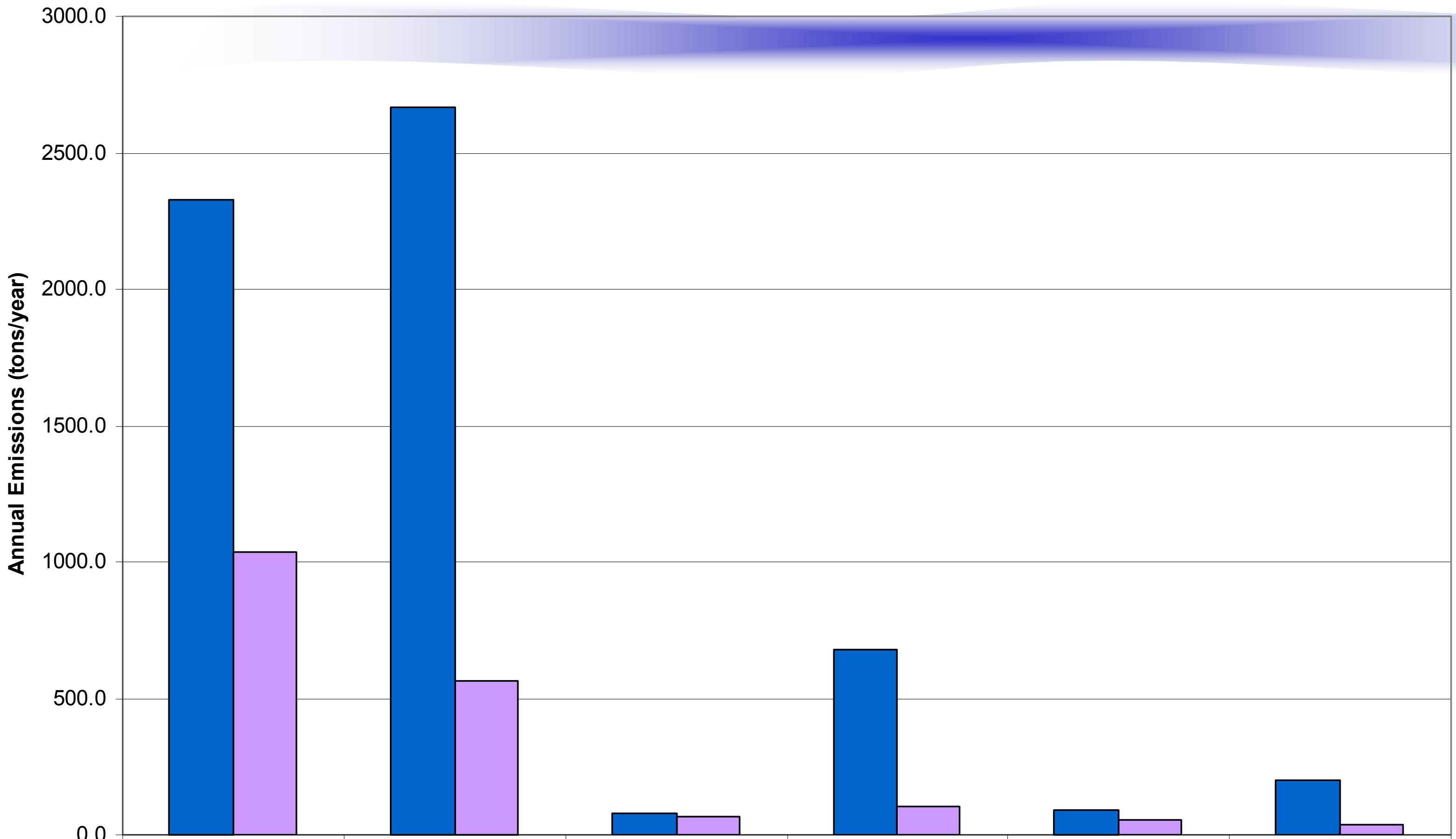
# NESCAUM/SIP Comparison




| | MA-Logan | NESCAUM Logan | CT-Bradley 1996 | NESCAUM Bradley | NH-Manchester 1996 | NESCAUM Manchester |
|---|---|---|---|---|---|---|
| NOx | 2330.0 | 2664.3 | 79.2 | 676.5 | 92.5 | 197.5 |
| VOC | 1038.0 | 562.1 | 63.9 | 102.0 | 52.9 | 35.4 |

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# Aircraft Emission Summary

- NESCAUM Model is more detailed and simpler than EDMS
- NESCAUM method incorporates more exact input data
- NOx emissions are higher than states have estimated
- APU emissions are about 5% of aircraft emissions

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